

What is claimed is:

1. A non-invasive method of monitoring operational readiness of electric power storage batteries in an uninterruptible power supply (UPS) system, the UPS system having at least one battery channel, each having at least two battery packs coupled in series to supply output power to a connected load and a battery charger to maintain and restore charge to the batteries during normal utility line operation, comprising the steps of:

monitoring a voltage at a midpoint between the two battery packs during a quiescent state of operation of the battery packs;
comparing the voltage to a first nominal value for the midpoint voltage during the quiescent state of operation of the battery packs;
indicating a lack of operational readiness of both battery packs when the voltage at the midpoint is less than the first nominal value by a first predetermined amount.

2. The method of claim 1, wherein the UPS system includes a plurality of battery channels coupled in parallel with one another, and wherein the step of monitoring comprises the step of monitoring a voltage for each of the parallel coupled battery channels at a midpoint between the two battery packs during a quiescent state of operation, the method further comprising the steps of:

calculating the first nominal value for the midpoint voltage during the quiescent state of operation of the battery packs as the average of the voltages monitored for each parallel coupled battery channel; and

indicating a lack of operational readiness of a battery channel when the voltage at the midpoint of the battery packs for that channel is less than the first nominal value by the first predetermined amount.

3. The method of claim 1, further comprising the steps of:
monitoring the voltage at a midpoint between the two battery packs during float charging of the battery packs;

comparing the voltage to a second nominal value for the midpoint voltage during the float charging of the battery packs;

indicating a lack of operational readiness of one of the two battery packs when the

voltage at the midpoint varies from the second nominal value by a second predetermined amount.

4. The method of claim 3, wherein the step of indicating a lack of operational readiness of one of the two battery packs comprises the step of indicating a lack of operational readiness of a first one of the two battery packs when the voltage at the midpoint is greater than the second nominal value by the second predetermined amount.

5. The method of claim 3, wherein the step of indicating a lack of operational readiness of one of the two battery packs comprises the step of indicating a lack of operational readiness of a second one of the two battery packs when the voltage at the midpoint is less than the second nominal value by the second predetermined amount.

6. The method of claim 3, wherein the UPS system includes a plurality of battery channels coupled in parallel with one another, and wherein the step of monitoring comprises the step of monitoring a voltage for each of the parallel coupled battery channels at a midpoint between the two battery packs during the float charging, the method further comprising the steps of:

calculating the second nominal value for the midpoint voltage during the float charging of the battery packs as the average of the voltages monitored for each parallel coupled battery channel; and

indicating a lack of operational readiness of a battery channel when the voltage at the midpoint of the battery packs for that channel varies from the second nominal value by the second predetermined amount.

7. The method of claim 6, wherein the step of indicating a lack of operational readiness of a battery channel comprises the step of indicating a lack of operational readiness of a first one of the two battery packs of that battery channel when the voltage at the midpoint is greater than the second nominal value by the second predetermined amount.

8. The method of claim 3, wherein the step of indicating a lack of operational readiness of a battery channel comprises the step of indicating a lack of operational readiness of a second one of the two battery packs of that battery channel when the voltage at the midpoint is less than the second nominal value by the second predetermined amount.

9. The method of claim 1, further comprising the steps of:
monitoring the voltage at a midpoint between the two battery packs at a state of discharge of the battery packs;
comparing the voltage to a third nominal value for the midpoint voltage during the state of discharge of the battery packs;
indicating a lack of operational readiness of one of the two battery packs when the voltage at the midpoint varies from the third nominal value by a third predetermined amount.

10. The method of claim 9, wherein the step of indicating a lack of operational readiness of one of the two battery packs comprises the step of indicating a lack of operational readiness of a first one of the two battery packs when the voltage at the midpoint is less than the third nominal value by the third predetermined amount.

11. The method of claim 9, wherein the step of indicating a lack of operational readiness of one of the two battery packs comprises the step of indicating a lack of operational readiness of a second one of the two battery packs when the voltage at the midpoint is greater than the third nominal value by the third predetermined amount.

12. The method of claim 9, wherein the UPS system includes a plurality of battery channels coupled in parallel with one another, and wherein the step of monitoring comprises the step of monitoring a voltage for each of the parallel coupled battery channels at a midpoint between the two battery packs during the state of discharge, the method further comprising the steps of:

calculating the third nominal value for the midpoint voltage during the state of discharge of the battery packs as the average of the voltages monitored for each parallel

coupled battery channel; and

indicating a lack of operational readiness of a battery channel when the voltage at the midpoint of the battery packs for that channel varies from the third nominal value by the third predetermined amount.

13. The method of claim 12, wherein the step of indicating a lack of operational readiness of a battery channel comprises the step of indicating a lack of operational readiness of a first one of the two battery packs of that battery channel when the voltage at the midpoint is less than the third nominal value by the third predetermined amount.

14. The method of claim 12, wherein the step of indicating a lack of operational readiness of a battery channel comprises the step of indicating a lack of operational readiness of a second one of the two battery packs of that battery channel when the voltage at the midpoint is greater than the third nominal value by the third predetermined amount.

15. A method of detecting and identifying a failed battery pack in an uninterruptible power supply (UPS) system, the UPS system having a plurality of parallel connected slots into which may be coupled battery packs, power modules, or battery chargers as determined and configured by a user, the slots being adapted to accommodate two battery packs and providing a series coupling therebetween, the method comprising the steps of:

detecting a presence and type of equipment installed in each slot;

monitoring a voltage present at the series coupling between the two battery packs for each slot into which is installed battery packs;

calculating an average midpoint voltage for all slots having battery packs installed therein;

comparing the voltage for each slot to the average midpoint voltage for all slots; and

identifying a failed battery pack within a slot when the voltage for its associated slot deviates from the average midpoint voltage by a predetermined amount.

16. The method of claim 15, further comprising the steps of:

comparing the voltage for each slot to a predetermined expected value; and identifying a failed battery pack within a slot when the voltage for its associated slot deviates from the predetermined expected value by a predetermined amount.

17. The method of claim 16, further comprising the step of determining an operating mode of the battery packs, and wherein the step of comparing the voltage for each slot to a predetermined expected value comprises the step of comparing the voltage for each slot to an operating mode specific predetermined expected value, and wherein the step of identifying a failed battery pack within a slot when the voltage for its associated slot deviates from the predetermined expected value by a predetermined amount comprises the step of identifying a failed battery pack within a slot when the voltage for its associated slot deviates from the operating mode specific predetermined expected value by a predetermined amount.

18. The method of claim 17, wherein the step of determining an operating mode of the battery packs determines that the battery packs are operating in a quiescent mode, and wherein the step of identifying a failed battery pack within a slot comprises the step of identifying both battery packs as failed when the voltage for their associated slot is less than a first predetermined value by a first predetermined amount.

19. The method of claim 17, wherein the step of determining an operating mode of the battery packs determines that the battery packs are operating in a float charging mode, and wherein the step of identifying a failed battery pack within a slot comprises the step of identifying a first one of the two battery packs within the slot as failed when the voltage for its associated slot is less than a second predetermined value by a second predetermined amount, and identifying a second one of the two battery packs within the slot as failed when the voltage for its associated slot is greater than a third predetermined value by a third predetermined amount.

20. The method of claim 17, wherein the step of determining an operating mode of the battery packs determines that the battery packs are operating in a discharging mode, and wherein the step of identifying a failed battery pack within a slot comprises the step of identifying a first one of the two battery packs within the slot as failed when the voltage for its associated slot is less than a fourth predetermined value by a fourth predetermined amount, and identifying a second one of the two battery packs within the slot as failed when the voltage for its associated slot is greater than a fifth predetermined value by a fifth predetermined amount.

21. The method of claim 15, wherein the step of detecting a presence and type of equipment installed in each slot comprises the step of polling each slot for an equipment type identifier.

22. A system for detecting defective battery packs in a modular, redundant uninterruptible power supply (UPS) system, the UPS system having a plurality of parallel connected slots into which may be coupled the battery packs, power modules, or battery chargers as determined and configured by a user, each slot being adapted to accommodate two battery packs and to provide a series coupling therebetween, the system comprising:

a voltage sense circuit coupled to each series coupling of each slot and operable to generate a voltage sense signal in response to a voltage present thereon;

a voltage sense selector circuit coupled to each of the voltage sense circuits, the voltage sense selector circuit operable to selectively enable the voltage sense circuits;

a controller operably coupled to the voltage sense selector circuit to command the voltage sense selector circuit to enable of a particular voltage sense circuit for a particular slot, the controller reading the voltage sense signal for the particular slot from the voltage sense circuit; and

wherein said controller compares the voltage sense signal for the particular slot to a predetermined expected value and identifies an operational status of the battery packs based thereon.

23. The system of claim 22, wherein the controller reads the voltage sense signal for each slot in which battery packs are installed, calculates an average voltage value, and compares the voltage sense signal for each slot to the average voltage value to identify the operational status of the battery packs for each slot.

24. The system of claim 23, wherein the controller reads the voltage sense signal for each slot in which battery packs are installed during a float charge mode, compares the voltage sense signal for each slot to an expected voltage value for the float charge mode, and identifies a first one of the battery packs in a slot as defective when the voltage sense signal for the associated slot is less than the expected voltage value for the float charge mode, and identifies a second one of the battery packs in a slot as defective when the voltage sense signal for the associated slot is greater than the expected voltage value for the float charge mode.

25. The system of claim 23, wherein the controller reads the voltage sense signal for each slot in which battery packs are installed during a discharge mode, compares the voltage sense signal for each slot to an expected voltage value for the discharge mode, and identifies a first one of the battery packs in a slot as defective when the voltage sense signal for the associated slot is less than the expected voltage value for the discharge mode, and identifies a second one of the battery packs in a slot as defective when the voltage sense signal for the associated slot is greater than the expected voltage value for the discharge mode.

26. The system of claim 22, wherein the voltage sense selector circuit comprises a shift register having a clock input and a slot select input from the controller, the shift register sequentially generating a plurality of output enable signals in response to the clock input and the slot select input from the controller, each of the output enable signals operative to turn on a switching element to connect the voltage sense circuit to the controller.

27. The system of claim 26, wherein the switching element is a metal oxide silicon field effect transistor (MOSFET).

28. An electrical cabinet for configuring an uninterruptible power system, the cabinet comprising a plurality of receiving locations each adapted to receive either of a power module and a battery pack, each receiving location including at least one terminal connector comprising a first power connector adapted to electrically connect with the battery pack and a signal connector adapted to electrically connect with the power module.

29. The electrical cabinet of claim 28, wherein each receiving location includes a first terminal connector and a separate second terminal connector arranged in non-interfering locations.

30. The electrical cabinet of claim 28 wherein the signal connector and the power connector are arranged in a single terminal connector along a common strip.

31. The electrical cabinet of claim 30 wherein the power modules are adapted to connect to the power connector in addition to the signal connector.

32. The electrical cabinet of claim 28 further comprising partitions dividing the receiving locations into slots.

33. The electrical cabinet of claim 28 further comprising a user interface adapted to provide a status of each receiving location that is indicative of the use of the receiving location.

34. The electrical cabinet of claim 33 wherein each receiving location comprises sensing means indicating to the user interface the type of device positioned in the receiving location.

35. The electrical cabinet of claim 28 wherein each receiving location is adapted to receive at least two battery packs, and wherein each said receiving location includes a pair of said first terminal connectors, one first terminal connector for each different battery pack.

36. The electrical cabinet of claim 28 wherein each power module includes a fan, each receiving location including a vent arranged to be in close proximity to the fan of a power module positioned therein.

37. The electrical cabinet of claim 28, further comprising:
a support base;
support bars spaced apart in rectangular relationship extending vertically and parallel from the support base;
side panels extending vertically and generally parallel between different pairs of the four support posts; and
a plurality of shelves extending horizontally between the four support posts in spaced apart parallel relationship, the receiving locations being defined between adjacent shelves; and
a back panel associated with the receiving location, the back panel extending generally perpendicular to the shelves and transversely between the side panels and two of

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the support bars, the back panel supporting the at least one terminal connector.

38. The electrical cabinet of claim 37 wherein the shelves, the side panels, and the support bars are manufactured from sheet metal material, pairs of the support bars being connected and maintained in spaced relation by a web of sheet metal material.

39. The electrical cabinet of claim 28, wherein said plurality of receiving locations are also adapted to receive a battery charger, and wherein said first power connector and said signal connector are adapted to electrically connect with the battery charger.

40. An electrical cabinet for configuring an uninterruptible power system with battery packs and modules, comprising:

a support housing:

a plurality of universal bays defined in the support housing, each universal bay sized to receive either of a battery pack and a power module; and

at least one terminal connector for each universal bay, comprising a first power connector adapted to electrically connect with the battery pack and a signal connector adapted to electrically connect with the power module.

41. The electrical cabinet of claim 40, wherein each universal bay includes a first terminal connector and a separate second terminal connector arranged in non-interfering locations.

42. The electrical cabinet of claim 41 wherein the housing defines a guide surface for each universal bay adapted to guide the battery pack into electrical connection with the first power connector and guide the power module into electrical connection with the signal connector.

43. The electrical cabinet of claim 42 wherein each of the signal and power connectors include a guide mechanism which interacts with a corresponding guide mechanism on either of the battery pack and power module, wherein the guide surface is

adapted to first locate the corresponding guide mechanisms for interaction, and then the respective corresponding guide mechanisms guide the battery packs and power modules into electrical connection with the power connectors and signal connectors, respectively.

44. The electrical cabinet of claim 40 wherein the signal connector and the power connector are arranged in a single terminal connector along a common strip.

45. The electrical cabinet of claim 44 wherein the power module is adapted to connect to the power connector in addition to the signal connector.

46. The electrical cabinet of claim 40 further comprising a user interface adapted to provide a status of each universal bay that is indicative of the use of the universal bay.

47. The electrical cabinet of claim 46 wherein each universal bay comprises a sensor means indicating to the user interface the type of device positioned in the universal bay.

48. The electrical cabinet of claim 40, wherein the support housing comprises:

- a support base;
- support bars spaced apart in rectangular relationship extending vertically and parallel from the support base;
- side panels extending vertically and generally parallel between different pairs of the four support posts; and
- a plurality of shelves extending horizontally between the four support posts in spaced apart parallel relationship, the universal bays being defined between adjacent shelves;

and

a back panel associated with the universal bays, the back panel extending generally perpendicular to the shelves and transversely between the side panels and two of the support bars, the back panel supporting the at least one terminal connector.

49. The electrical cabinet of claim 48 wherein the shelves, the side panels, and the support bars are manufactured from sheet metal material, pairs of the support bars being connected and maintained in spaced relation by a web of sheet metal material.

50. The electrical cabinet of claim 49 wherein the back panel comprises a printed circuit board backplane.

51. The electrical cabinet of claim 40 wherein each battery pack is dimensioned to be about one half the size of a power module, such that each universal bay is adapted to receive either of two battery packs side by side and a power module.

52. The electrical cabinet of claim 40, wherein each universal bay is sized to additionally receive a battery charger, and wherein said at least one terminal connector for each universal bay is adapted to electrically connect to said battery charger.

53. A back panel for use in an electrical cabinet of a modular uninterruptible power supply (UPS) system, the UPS being capable of including any combination or exclusion of battery packs, power modules, and battery chargers within the capacity of the electrical cabinet, the electrical cabinet having a plurality of identical receiving locations capable of receiving any one of the power modules, battery packs, and battery chargers, the back panel comprising:

a backplane; and

a first terminal connector, said terminal connector comprising:

a power connector mounted on said backplane and adapted to electrically connect with the battery pack, the power module, and the battery charger; and

a signal connector mounted on said backplane and adapted to electrically connect with the power module and the battery charger.

54. The back panel of claim 53, wherein said backplane comprises a printed circuit board having power traces and signal traces included therein said power traces

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and signal traces being operably coupled to said power connector and said signal connector, respectively.

55. The back panel of claim 53, further comprising a second terminal connector positioned in a non-interfering relationship with said first terminal connector.

56. The back panel of claim 53, further comprising a guide member rigidly mounted on said backplane, said guide member adapted to receive flanges on the battery packs, power modules, and battery chargers to ensure proper positioning of the battery packs, power modules, and battery chargers for engagement with the terminal connector.

57. An uninterruptible power system (UPS), comprising:
an electrical cabinet having a plurality of universal receiving locations defined therein, said universal receiving locations being adapted to receive battery packs and power modules;
a power module positioned within one of said universal receiving locations; and
a battery pack positioned within another one of said universal receiving locations.

57. The UPS of claim 57, wherein said universal receiving locations are further adapted to receive battery chargers, the UPS further comprising a battery charger positioned within a third of said universal receiving locations.

58. The UPS of claim 57, wherein each of said universal receiving locations comprises a terminal connector having a power connector and a signal connector positioned to electrically connect with both the power module and the battery pack upon insertion thereof.